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**DATE:** December 7, 2000 **Action Item #:** 1254

**RE:** AMS Configuration #5 Assessment

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The MAGIK Robotic Analysis Team has assessed a fifth configuration for the Alpha Magnetic Spectrometer on the S3 Truss. MAGIK Action Items 1110, 1146, 1174, and 1192 addressed four other configurations. This analysis addressed the robotic installation clearances to the AMS installed at the S3 Inboard Upper Payload Attach System (PAS).

A high fidelity model of the AMS with a modified debris shield was received from Ross Harold/Lockheed Martin in October, 2000 and was used in this analysis to assess robotic clearances.

### ***Assumptions:***

- Assembly operations completed at UF4 (Rev F Assembly Sequence) timeframe
- AMS manifest aft trunnion location is 1242.07 inches
- AMS manifest forward trunnion location is 1163.4 inches
- AMS manifest keel location is 1175.2 inches
- AMS is installed to S3 Inboard Upper PAS
- EXP is installed to S3 Outboard Upper PAS
- Distance (ISS +Y) from Inboard S3 PAS to Outboard S3 PAS is 113.38 inches

### ***Summary:***

The AMS installation operation was assessed, and violations of the Remote Manipulator System (RMS) Grapple Fixture (GF) approach envelopes and EVA Contingency Release envelopes were found. Violations of the SSRMS twenty-four inch requirement during AMS installation were also identified. These violations are severe enough to be brought to the End to End Berthing Integration Team (EBIT) for review. The Mission Operations Directorate (MOD) Robotics Section (DX22) and EVA Section (DX3) must also be consulted, and waivers must be granted for all 24 inch violations.

## ***Detailed Discussion:***

The AMS unberth and installation operation was assumed to occur as in the MAGIK Design Analysis Cycle #8 (DAC 8). The SpaceLab Logistics Pallet (SLP) carrying the manifested SPDM is removed first.

After the SLP is removed, the AMS is grappled by the SRMS. This fifth AMS configuration included a slightly different SRMS grapple fixture location, which eliminated the SRMS Approach envelope violation found in the last AMS configuration. The SRMS EVA Contingency Release Envelope, NSTS-21000-IDD-ISS section 14.4.2.1, is, however, violated by the AMS structure (Figure 1). MOD EVA (DX 3) would have to review this violation.

The AMS is unberthed and handed off to the SSRMS. The SSRMS Static Approach Envelope, NSTS-21000-IDD-ISS section 14.4.4.2-1, and the EVA Contingency Release Envelope, NSTS-21000-IDD-ISS section 14.4.2.2, for the SSRMS GF are violated (Figures 2 and 3, respectively).

MOD Robotics Section (DX22) and EVA Section (DX3) must be consulted and made aware of these approach envelope and EVA envelope violations. Unless the violations are eliminated, MOD must agree that they are insignificant, and waivers must be written.

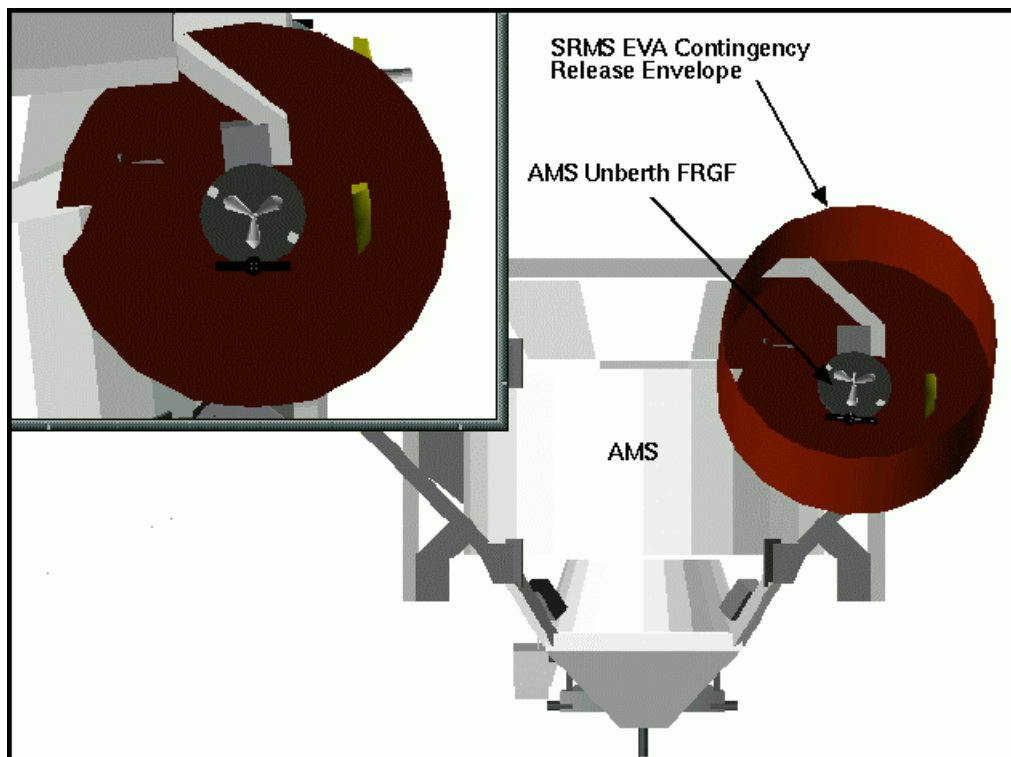


Figure 1 – SRMS EVA Contingency Release Envelope Violation

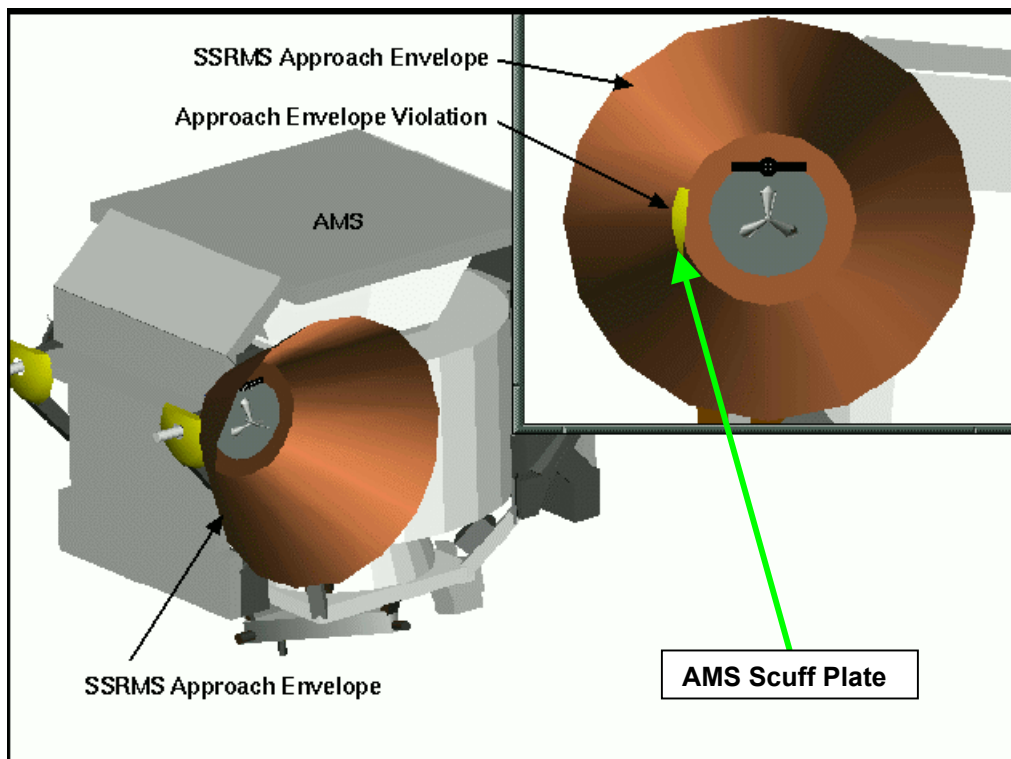


Figure 2 – SSRMS Approach Envelope Violation

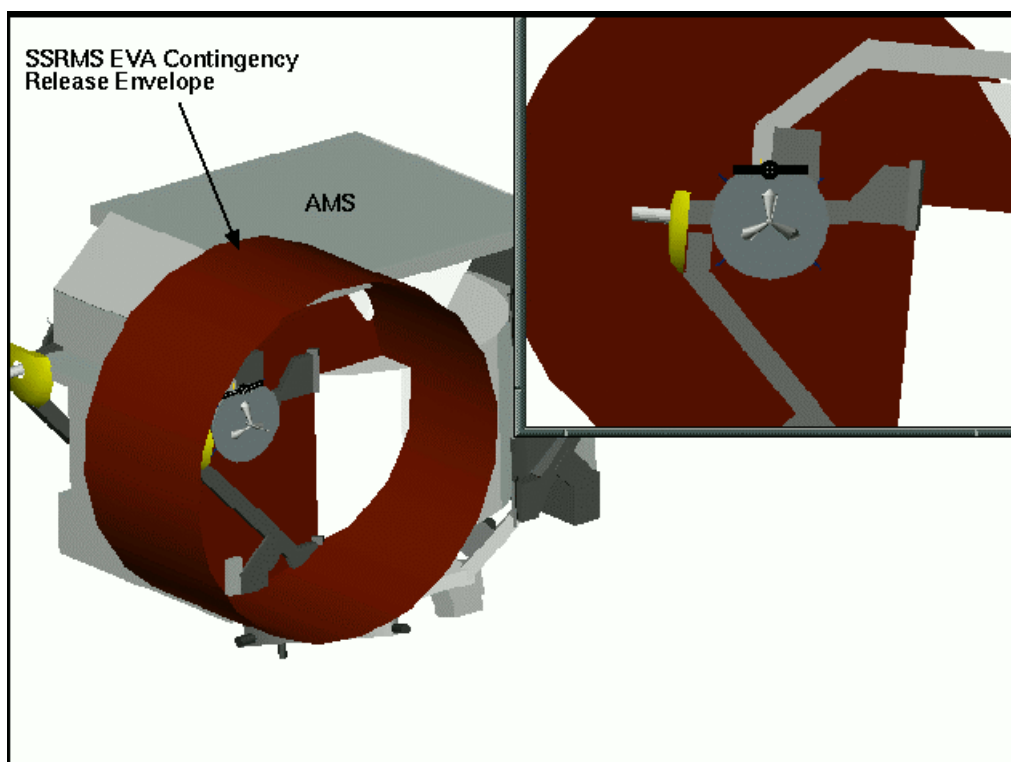


Figure 3 – SSRMS EVA Contingency Release Envelope Violation

The robotic installation of the AMS requires the SRMS unberth and hand off to the SSRMS. Figures 4 and 5 show the SRMS removing the AMS from the payload bay and handing off to the SSRMS, based on the Mobile Base Servicer System PDGF # 1, with the Mobile Transporter at S1 Bay 6, and the subsequent installation of the AMS to the S3 Inboard Upper Payload Attach Site (PAS).

It should be noted that the S1 Outboard Upper Truss Camera cannot be present when the AMS is installed to the truss, as the AMS structure physically interferes with the camera.

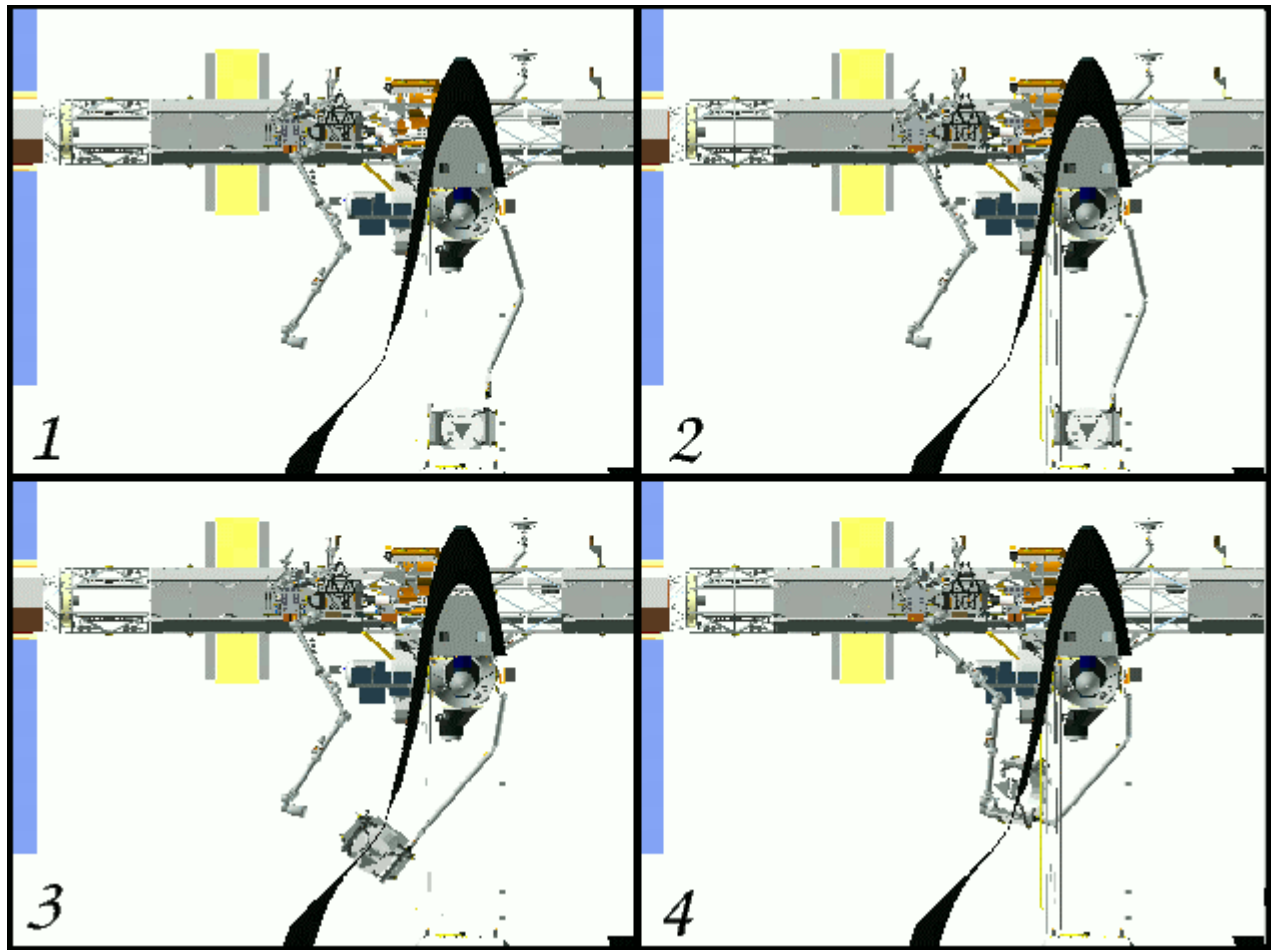


Figure 4 – AMS Robotic Assembly Operations (1-4 of 8)  
(ISS Front View)

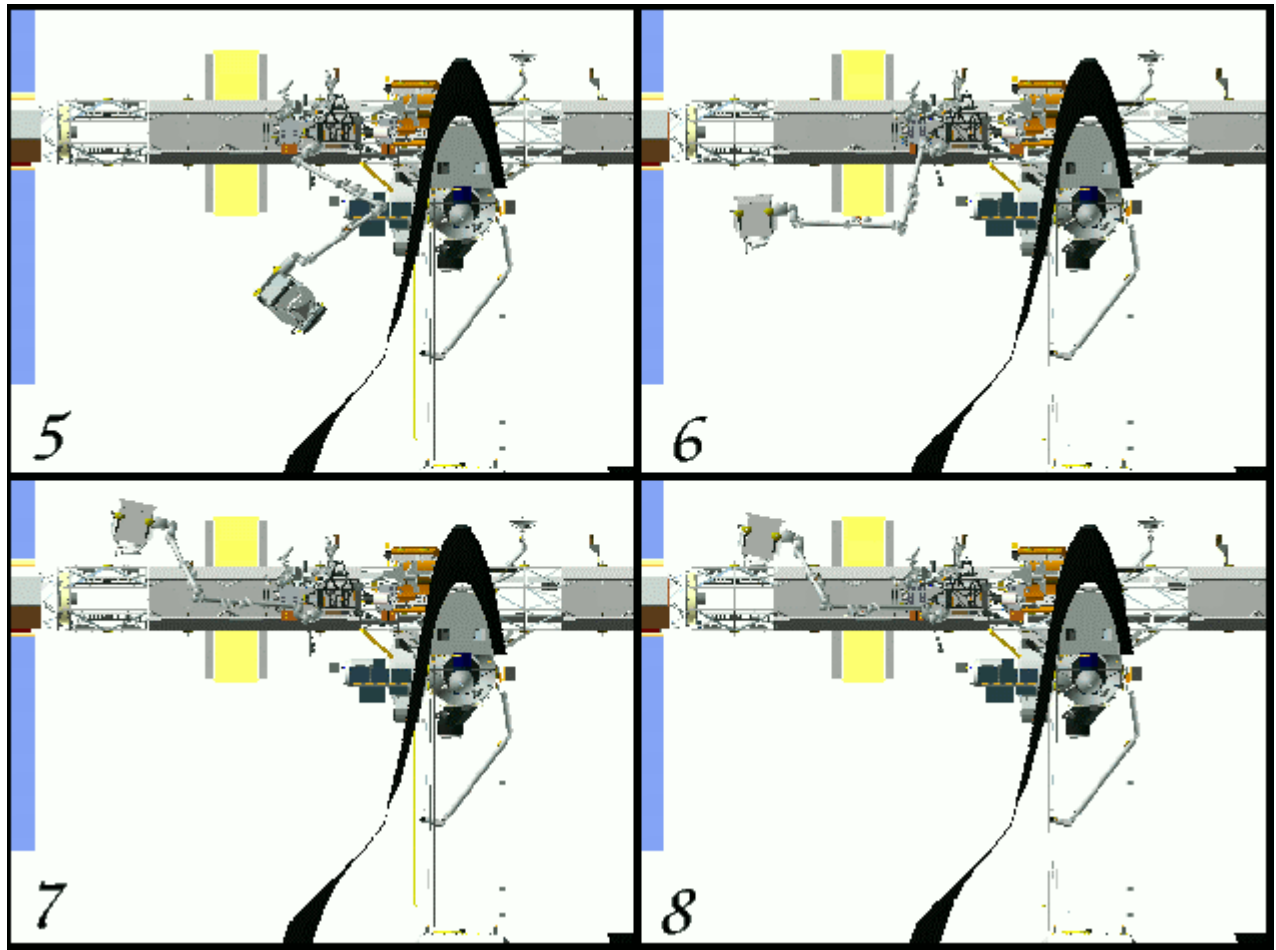


Figure 5 – AMS Robotic Assembly Operations (5-8 of 8)  
(ISS Front View)

MAGIK DAC 8 analysis documents the AMS as being installed before the Express Pallet. The following analysis shows the EXP present during the AMS installation for reference. Figure 6 shows the AMS 24 inches from being mated to the truss. As previously stated, the EXP is not currently baselined to be present during the AMS install, but if it were there, there would be only 15.3 inches from the AMS to the EXP structure.

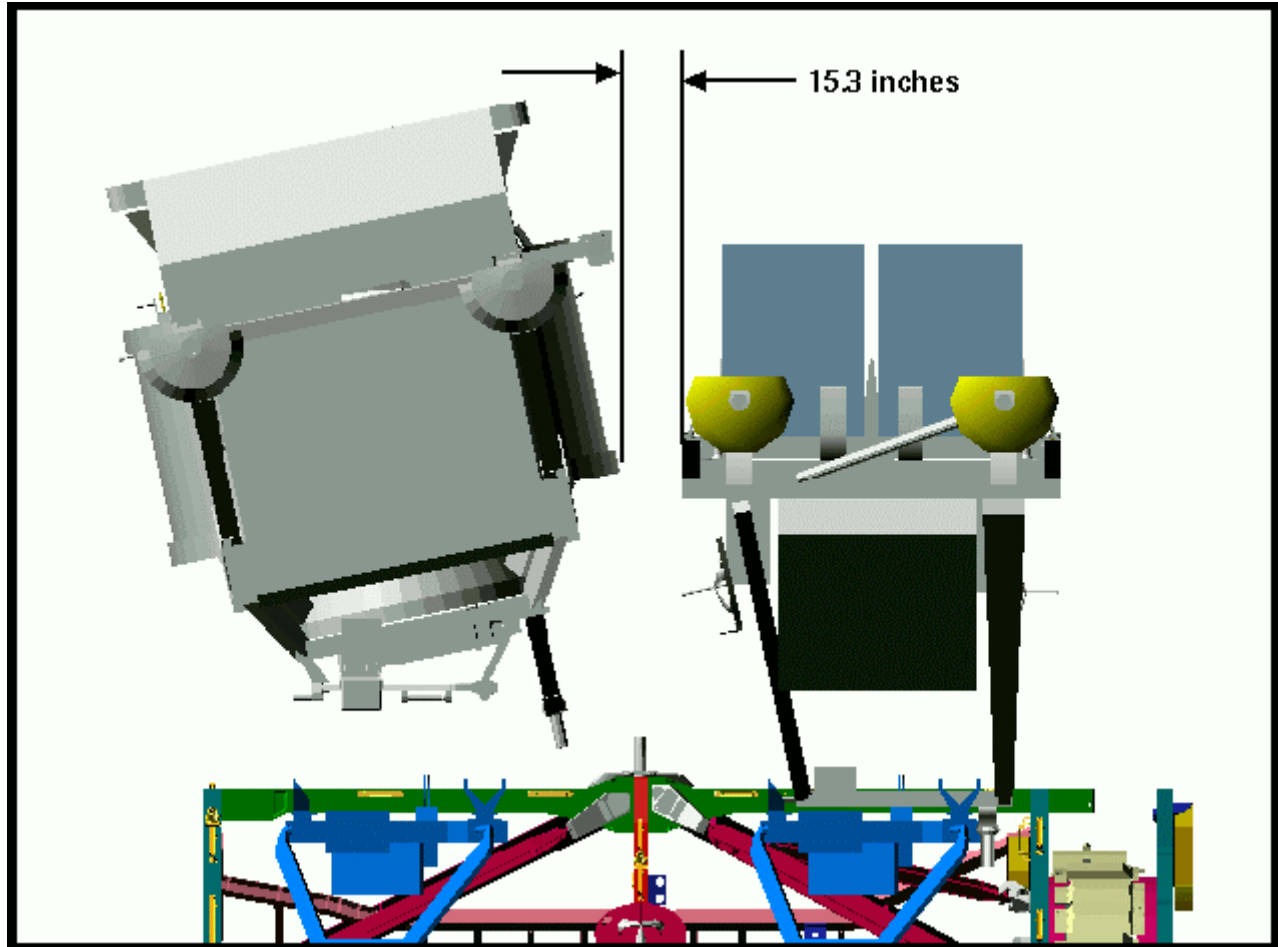


Figure 6 – AMS 24 inches from being mated to S3 truss  
(ISS Back View)

Figure 7 shows the clearances between the AMS and EXP and their respective PAS Payload Envelopes. The EXP protrudes through the Attached Payload Envelope making the clearance between the AMS and EXP smaller than the clearance between the AMS and the Payload Envelope.

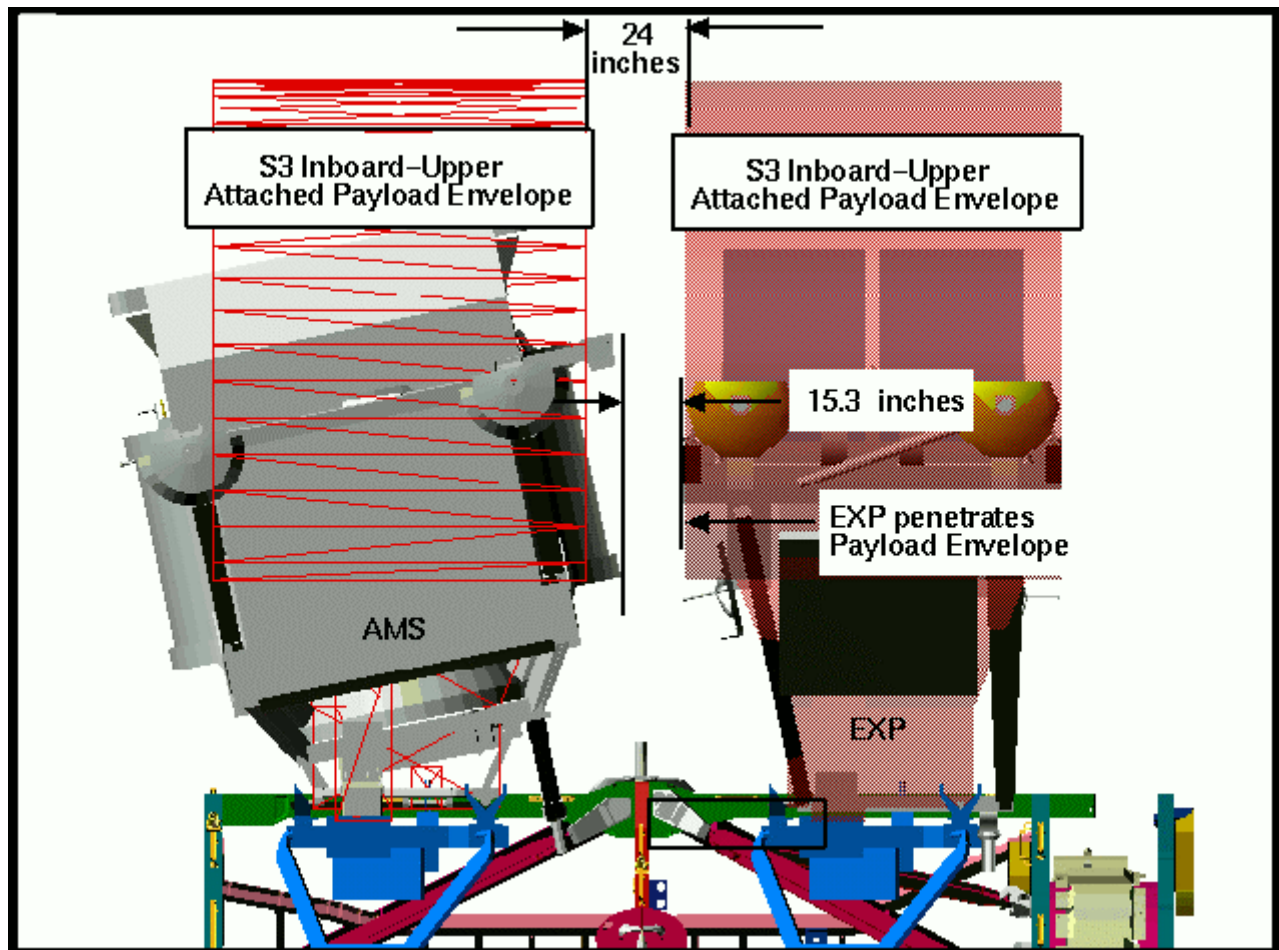


Figure 7 – AMS to EXP Clearances



As the AMS is berthed to the S3 Inboard Upper PAS, the keel structure comes close to the S3 truss structure. The closest clearance is 12 inches from the AMS keel structure to the S3 truss, and occurs when the AMS is fully berthed. This clearance, as well as the next closest clearance, 13 inches, is shown in Figure 8. These clearances improve the farther away the AMS is from its berth, even if the robotic misalignments of 2,2,2, used previously, are assumed.

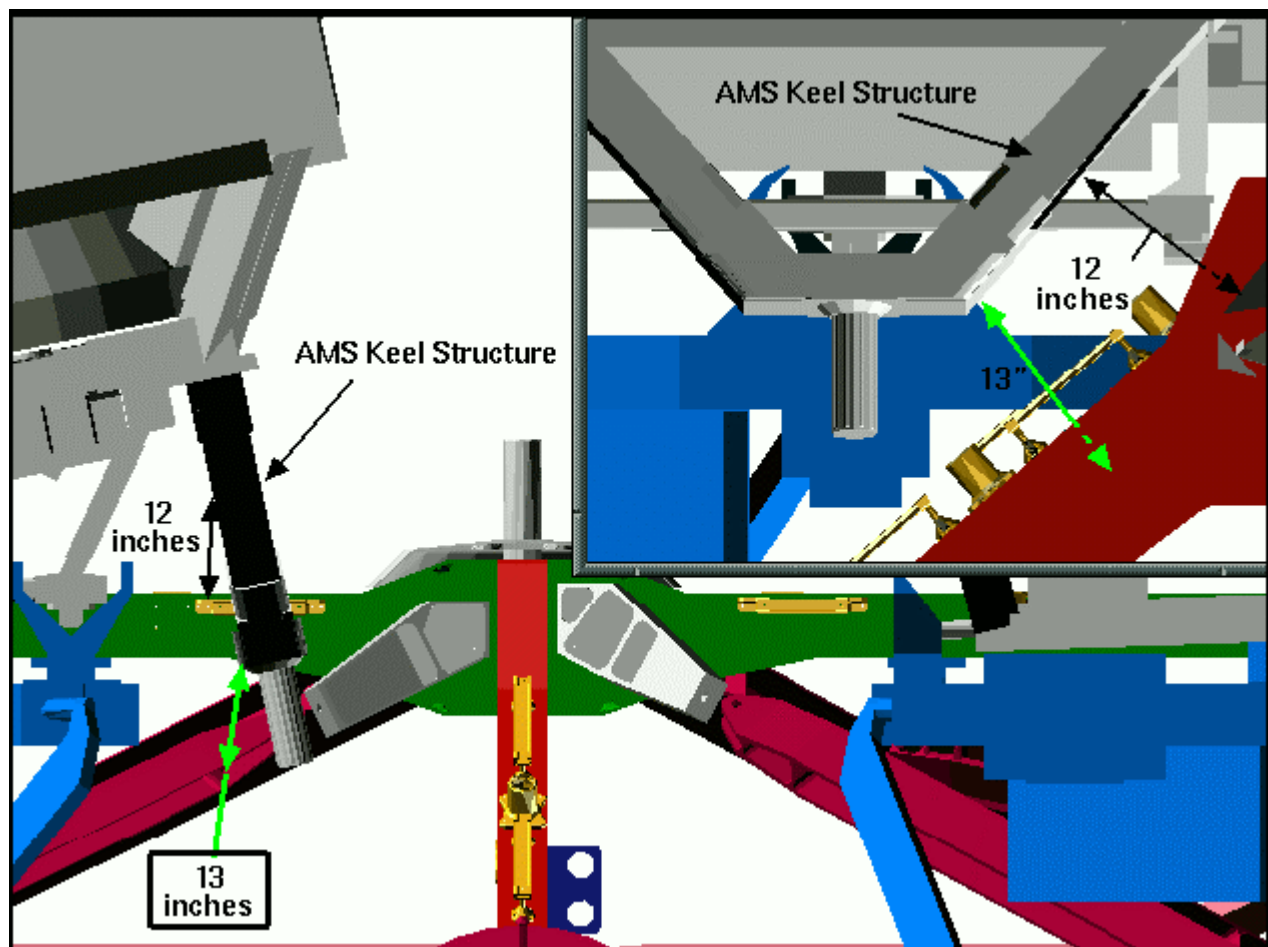


Figure 8 – AMS Keel to S3 = 12 inches



The clearances shown in Figure 8 are representative of a perfectly aligned mating operation. However, if any robotic misalignments are present, these clearances will be affected. For this analysis, the axis of rotation for the misalignments was assumed to be in the geometric center and on the same plane as the AMS PAS interface. If the point of resolution (POR) chosen by the Mission Operations Directorate (MOD) is different from this assumed POR, the clearances represented in Table 1 will be altered. Additional analysis may need to be done when the final POR is chosen.

MAGIK Action Item 1192 results were presented to the End to End Berthing Integration Team (EBIT) in August, 2000. The EBIT was concerned with the close clearances between the AMS and the Express Pallet. Three options were given to the AMS designers:

1. Design both elements to survive contact.
2. Increase clearances to allow 12 inches on top of the cues and operator errors given to be 2 degrees wobble, 2 inches lateral offset, and 2 degrees roll.
3. Phase AMS and EXP so that only one of them is installed to the PAS at a time and the other PAS remains vacant.

The clearances from the AMS keel and structure to surrounding structure are given in Table 1 below for only the 2,2,2 case of misalignment. These clearances and misalignment issues must be reviewed by the EBIT. It should also be noted that these clearances do not take into account any manufacturing tolerances or thermal deformations which may be present. The models used for the analysis represent as-designed, and the as-built hardware could be larger or smaller which will affect the clearances shown below.

<b>Distance Between Passive And Active Halves of PAS (inches)</b>	<b>Tilt (Wobble) (degrees)</b>	<b>Lateral Translation (inches)</b>	<b>Roll (degrees)</b>	<b>AMS to EXP Structure (inches)</b>	<b>See Figure #</b>
0	0	0	0	20.2	
12	0	0	0	16.1	7
24	0	0	0	15.3	6
12	2	2	2	12.6	9
19	2	2	2	11.5	10
34	2	2	2	11.5	

Table 1 – AMS Misalignments on Approach to S3 while EXP is Present

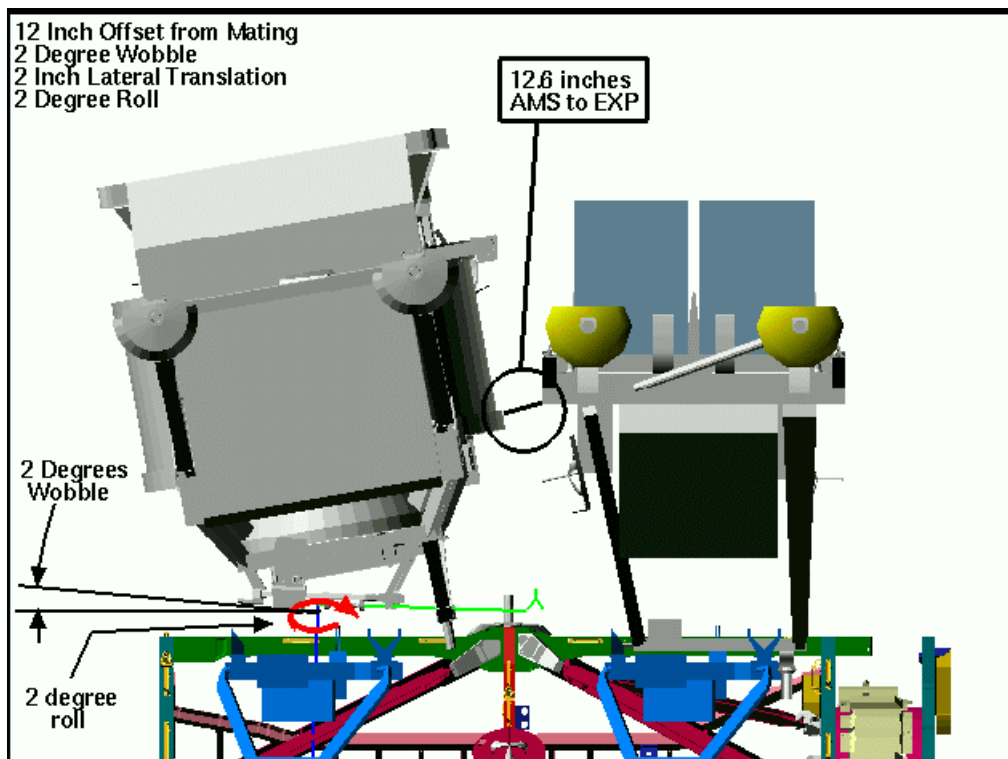


Figure 9 – AMS 12 inches away from berth, 2 Wobble, 2 Lateral, 2 Roll  
(ISS Back View)

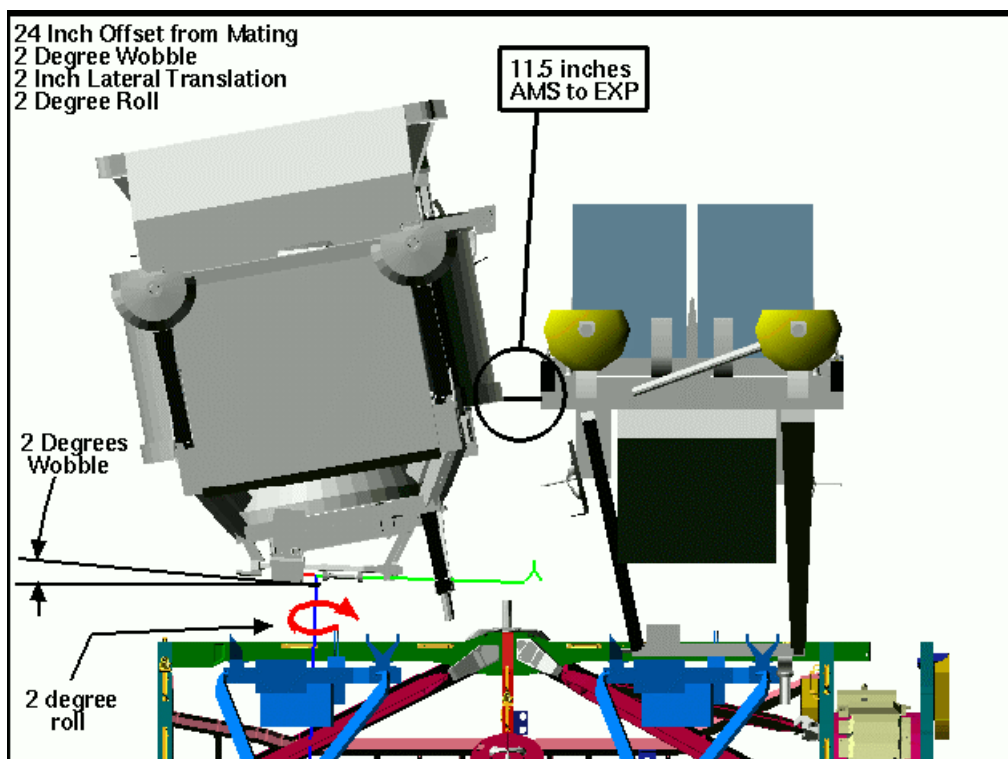


Figure 10 – AMS 24 inches away from berth, 2 Wobble, 2 Lateral, 2 Roll  
(ISS Back View)

One critical element in determining whether clearance violations are waiverable is the possible viewing of the operation. The S3 aft camera provides a view of the AMS installation to the S3 PAS site, although, this location is baselined to have a Wireless Video System (WVS) installed instead of a truss camera. If this viewing is deemed necessary, MOD must be consulted and a new camera configuration baseline must be established. Figure 11 shows the view from the S3 aft camera of the AMS at a point 36 inches from its berth.

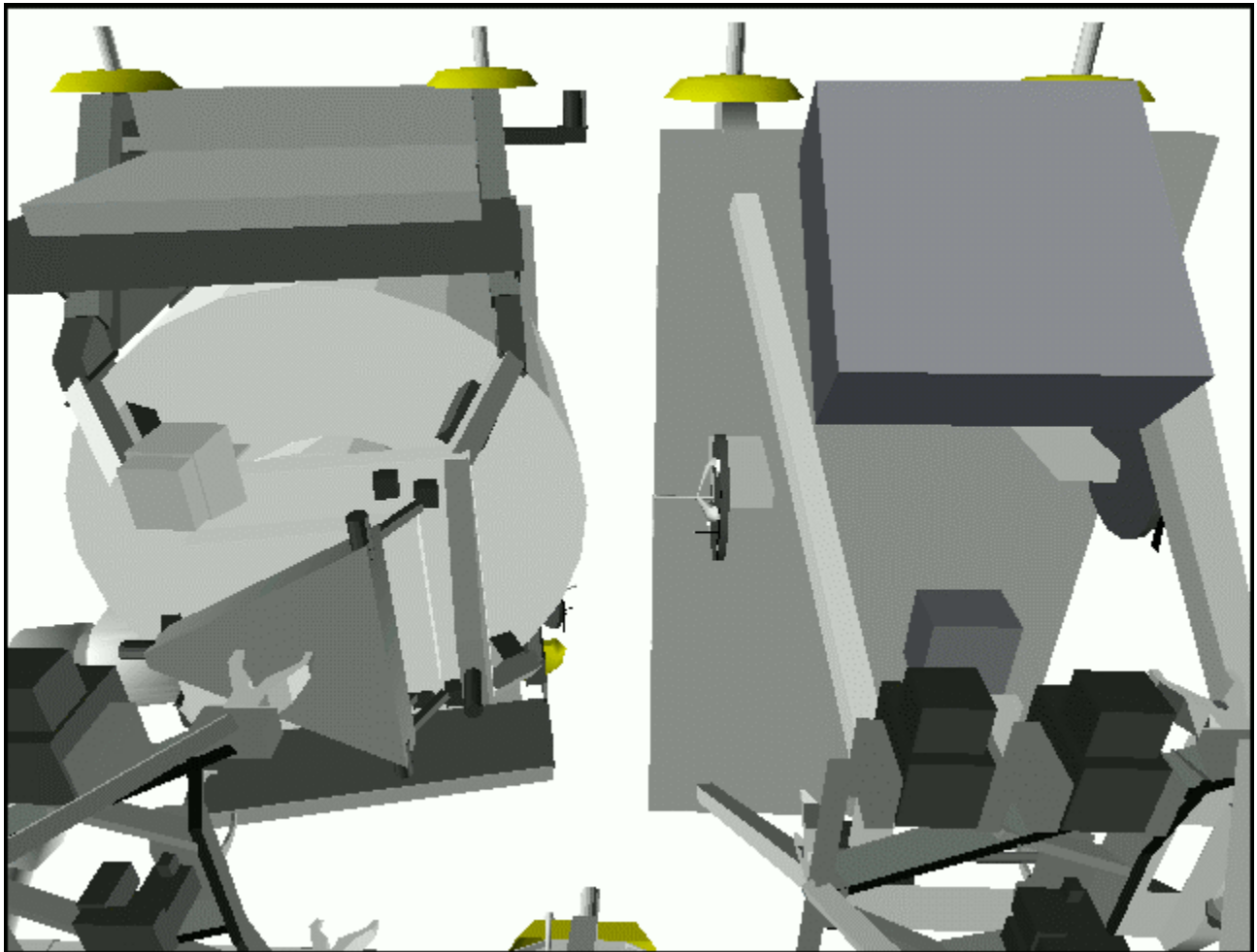


Figure 11 – View from S3 Aft Camera of AMS installation to S3 Inboard Upper PAS

The baselined operation of installing the EXP after the AMS is installed to the S3 truss was assessed for clearances. Using the same misalignments as were assumed for the AMS approach, the EXP approach clearances are slightly worse. The worst case clearances from the EXP to the AMS occur when the EXP is between 19 and 30 inches from its berth. This is due to the proximity of the AMS's ROEU to the EXP pallet top. Table 2 shows these clearances from the EXP to the AMS, and Figure 12 shows the EXP 19 inches from its berth. These clearances, like the AMS berthing clearances, are under the required twenty-four inch distance. The EBIT must consider these clearances as well as the AMS berthing clearances before a waiver may be granted for this operation.

<b>Distance Between Passive And Active Halves of PAS (inches)</b>	<b>Tilt (Wobble) (degrees)</b>	<b>Lateral Translation (inches)</b>	<b>Roll (degrees)</b>	<b>EXP to AMS Structure (inches)</b>
0	0	0	0	11.9
12	0	0	0	19.2
24	0	0	0	16.9
12	2	2	2	11.4
15	2	2	2	10.0
16	2	2	2	9.7
19	2	2	2	9.2
30	2	2	2	9.4
45	2	2	2	10.3
50	2	2	2	12.6

Table 2 – EXP Misalignments on Approach to S3 while AMS is Present

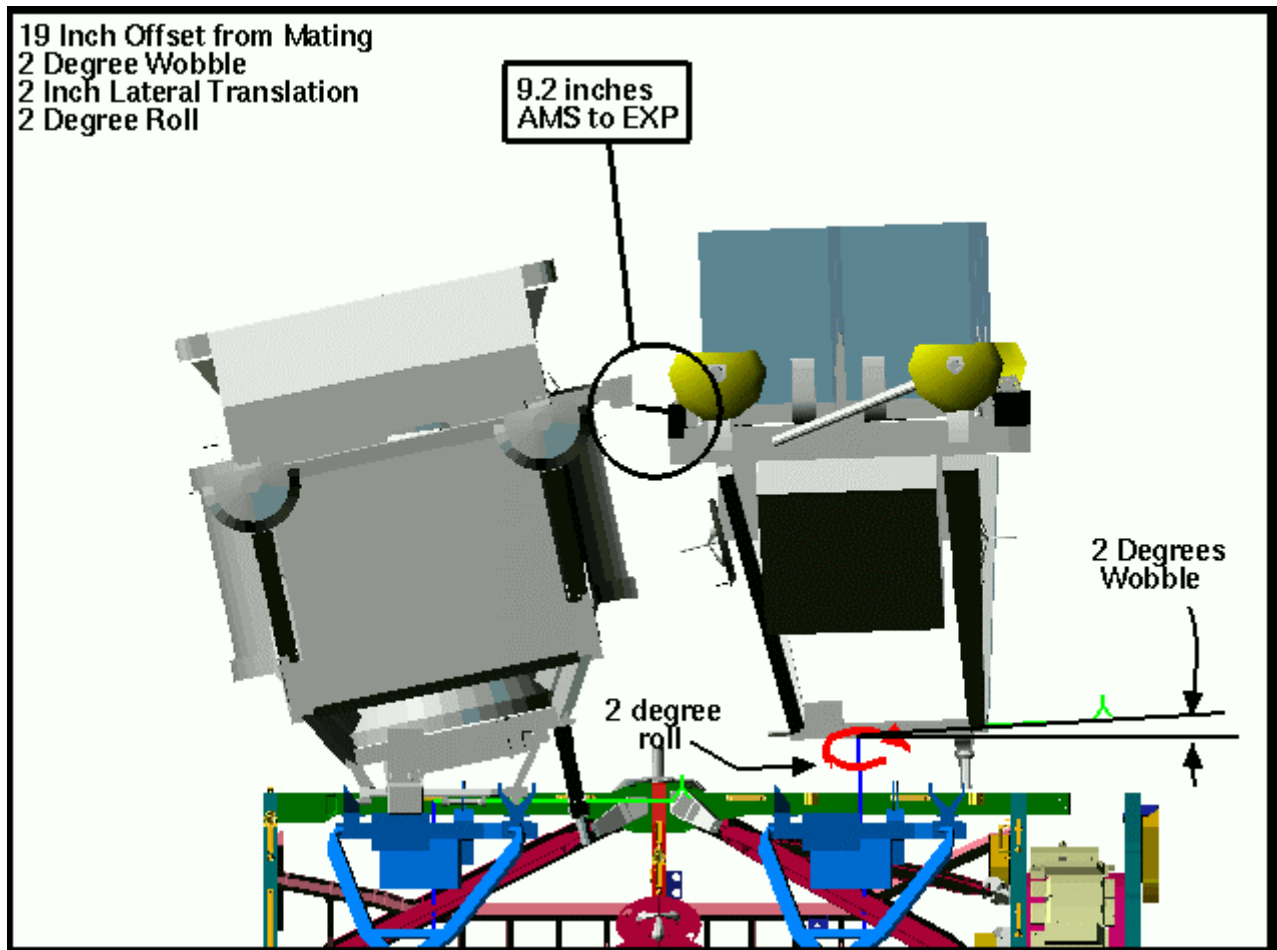


Figure 12 – EXP 19 inches from berth – 2 degree pitch, 2 inch lateral offset, 2 degree roll – ISS Back View